

CHEMISTRY

In its Relation to the Arts
and Manufactures.

— BY —

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In discussing a subject such as you have asked me to bring before you to-night, it is only possible for me to take up the matter in a general way, more with reference to the industries of Canada, and, at the same time, to consider how best these industries may be benefited and developed by the application to them of sound, general and scientific training. Chemistry may be defined as the science which deals with the composition of matter, and, as all industries of whatever nature involve chemical processes of one kind or another, it may safely be said that no industry can succeed without chemistry. It would be impossible, and, indeed, out of place, to discuss any special branch or branches of the arts relating to the many interests at work throughout the Dominion, and represented by the members of this Association. We have purely chemical processes being carried on, the making of acids, alkalies and chemicals in London, Ont.; drugs and soaps at our very doors, and explosives in Hamilton. Besides these, there are iron works, steel works at Hamilton and Midland, cement at Owen Sound, paper, pulp, leather, sugar refining and the production of nickel steel. More

recent articles of trade, such as carbide, for the making of acetylene for illuminating and heating purposes, carborundum and the metal aluminum are being produced comparatively near at hand. All these industries have been dependent on chemistry, and, as knowledge of that science has increased, so in like manner have processes improved, more perfect articles been produced, and the comforts of life—not to mention wealth—been augmented. To the trained chemist, aided by the engineer and the man of business, we are indebted for this, and on looking back into the lives of many of this world's greatest chemists—famous in the domain of theoretical chemistry—we find that most of them devoted a no inconsiderable amount of their time and energies to eminently practical points relating to the arts and manufactures. John Dalton, of Manchester, whose atomic theory is, so to speak, the creed of the modern chemist, interested himself in the industries of his native city. To him came the manufacturer and the dyer for information, and he was the universal referee in all matters pertaining to the purity of water and the genuineness of drugs. Playfair, of Edinburgh; Liebig; Hofmann; Thomas Anderson, of Glasgow, whose work on the pyridine bases is classic, all assisted in developing the industrial side of the science, while, on the other hand, we find men who were engaged in technical chemistry contributing to the literature of the times papers on purely theoretical deduction from phenomena observed during the progress of their ordinary avocation. One of the latter

—a chemical manufacturer—not only wrote a text book on chemistry, which may be found on the shelves of most university libraries, but contributed an excellent article to a contemporary entitled “On the Advantages of Literature and Philosophy in General, and Especially on the Consistency of Literary and Philosophical with Commercial Pursuits.” Looking as far back as 100 years, we find the chemist solving problems of vast industrial and national importance. During the Napoleonic wars, the supply of alkali for the manufacture of soap was cut off as a consequence of hostilities with Spain, from which country it had been almost exclusively imported in the form of “barilla.” The prospect of a soap famine was too much even for our Gallic brethren, and a valuable prize was offered by Napoleon for the best method of converting common salt into soda. This reward was gained by Leblanc, and to this day the process bearing his name is in use all over the world. There, the art of the chemist played its part; in the first operation for the conversion of common salt, large quantities of hydrochloric acid were evolved and allowed to escape into the air to the detriment of vegetation and health. This in later years was collected by absorption in large towers filled with coke, over which water was allowed to trickle, and from the acid thus saved is now manufactured bleaching powder and other substances indispensable to the arts. Among the former waste products might be mentioned “soda waste,” produced during the Leblanc process, and

which for years was neglected as useless. Now the chemist, by a simple and cheap process, in which atmospheric air and the waste acid before referred to play the principal part, obtains from it quantities of sulphur previously looked upon as irreclaimable. Again, we find that furnace gases can be utilized instead of being dissipated into the air, and the production of useful chemicals in this manner bears favorable comparison with the output of the main product aimed at.

Briefly, then, let us consider for a few moments some of the advances that chemistry has assisted to bring about in the direction of producing new commercial articles and utilizing available material. The iron and steel industries in Ontario bid fair to be reckoned soon among the largest in the world ; the pulp output, too, is enormous, and the supply of raw material almost inexhaustible. The chief natural source of the world's nickel supply is in Canada, at Sudbury, where huge quantities of *pyrrhotite* are found ; when nickel oxide or crude nickel is added to iron or steel, the resulting alloy is remarkable for its strength and elasticity, and is preferred before all others for the construction of armour plates, guns and other weapons. The actual methods of separating nickel from its ores and from the other metals associated with it present many difficulties, but, without doubt, in the course of time, the chemist and metallurgist will be able to reduce the cost of production considerably. In practically all metallurgical processes fuel is essential, both as a source of heat and as a

reducing agent, and a case in point occurs to me in which the directors of a company I know of, by not making sure of a convenient source of fuel, brought the undertaking into the hands of the liquidators.

The possibility of producing our own sugar supply from beets is at present looming large in the public eye. Given a proper supply of home-grown beets, there is no reason why the industry should not, in time, become a very large one. The chemistry of the sugars has now reached a high state of perfection, and much is known regarding the different kinds of sugars. Nevertheless, it is open to question whether cane and beet sugar are absolutely identical. One drawback to the latter kind is met with in the mother liquor or molasses ; it cannot be used for human consumption, owing to the small quantity of some poisonous substance or substances that it contains. The molasses from cane sugar, on the other hand, is familiar to all. Probably chemistry will find means to utilize the former variety for other purposes than at present. The crushed beets, after extraction, though containing only a small amount of sugar, could be utilized as fodder.

Of recent years, three new industries have sprung up close at hand which deserve mention as being the outcome of research in the domain of experimental chemistry. I refer to the production of carborundum, calcium carbide and aluminum by means of the electric furnace, for the working of which the falls at Niagara have been partially harnessed. The experiments which led to the discovery of carborundum were

made in 1891 by Mr. E. G. Acheson, who, like many other chemists, hoped to obtain carbon in a crystalline form. Clay and carbon were subjected to the temperature of the electric arc in an iron vessel lined with carbon. It was hoped that the aluminum produced by the reduction of the clay might dissolve some of the carbon, which would again separate out on cooling. Crystals of a very hard material were obtained, brittle and capable of scratching diamond. Further investigation showed that the new substance contained carbon and silicon only, discounting small traces of alumina, iron oxide, lime and magnesia, amounting in all to about 1 per cent. The use of clay in its manufacture was, therefore, stopped, and sand substituted. The new material has found many uses, principally as an abrasive, in the form of hones, as a substitute for emery paper, for polishing plate glass and hides. It is superior to emery, and it is claimed that carborundum can do twice the work of the same amount of emery, and with better results. Though only a child of nine years of age at present, it has already taken its place among chemical industries. During the first six years of its existence, the output rose from 15,000 lb. to nearly 800,000 lb., while the price of \$10 per lb. became reduced in the same period to 15c. Calcium carbide, too, as a commercial product, was first obtained during the preparation of aluminum, and immense quantities of it are now manufactured, both at Niagara and in Scotland, for the preparation of acetylene gas, so much used at the present time as an illuminant.

Let us now consider how best chemistry may be applied for the improvement and development of our national industries. Where new substances are to be produced or methods modified to meet the ever-increasing competition approaching from all sides, it is necessary that experiments be tried in the laboratory, and thereafter that plant be designed and constructed for the proper and economical carrying out of the work on the commercial scale. Here the services of the engineer and mechanic must supplement the knowledge of the chemist. It by no means follows that a process successful on the small scale will be equally so when carried out under trade conditions; the time taken to work out such practical problems is always great. Professor Barr, of Glasgow University, whose range-finder is now to be found on almost every battleship in the navies of Britain, the United States, Japan, and, I think, Germany also, informed me once that the principles on which this ingenious instrument is constructed were evolved in a few weeks, but the practical details of the manufacture required eight years of constant work before success crowned his efforts. The principles underlying the making of carbonate of soda by the Solvay process are known to all students of chemistry, but its practical working on the commercial scale required all the energies of such men as Bond and Solvay himself to be devoted to it before the industry became established on a sound footing. The matter of the proper training of men capable of taking an active part in the development of industries involving chemi-

cal processes in any way has for two years past occupied the close attention of the practical men in Great Britain. The eminent research chemist, Dr. W. H. Perkin, has expressed himself strongly on the need of drawing together the chemist and the constructor, and Mr. Geo. Beilby, the former President of the Society of Chemical Industry, has brought the subject under the notice of the most influential section of chemical manufacturers. One hears reiterated every day that "No good can come out of Nazareth," that is to say, that chemical manufactures are a dead letter in British dominions, and that in Germany only is the true home of industrial chemistry. In a measure this is true, but one has only to visit the large manufacturing towns in Britain to see that chemical industry is by no means dead, but, on the contrary, flourishing "like the green bay tree." Where are bichromate of potash and alum produced most cheaply? In London and in Glasgow. Where are the most extensive sugar refineries, leather works, soap works, iron and steel works? In the smoky towns of the Mother Country. Where are refined chemicals produced more cheaply than anywhere else, laboratory glassware and toys? In Germany. Where is pulp produced, iron, steel, nickel and agricultural implements? In Ontario. Each country has its own staple products, and the outcry regarding the decadence of our Imperial industries appears to me to be overdone. But this very outcry should be a warning and a safeguard; we must, so to speak, "to prevent war be prepared for war," and to be

prepared for the industrial war—not a mere guerrilla one either—which will surely come upon us from all sides, we must prepare ourselves and endeavour to improve our present resources to the utmost and agree as to the best means of doing so. I should like to quote from an address given three years ago by Dr. Edward Schunk, F.R.S., at the annual meeting of the Society of Chemical Industry:

“A great deal has been said of late as regards the dangers of our manufacturers from competition on the part of foreign producers. * * * From the speeches which are now and then made, one would infer that the danger is real and imminent, and that it behoves us with all possible speed to build and endow technical schools in which our workmen and others shall be trained so as to enable them to compete with the more highly educated classes of similar standing in Germany and France. I am myself too little in touch with the manufacturing industries of the present day to say whether the danger is real and present or merely apprehended and distant. If, however, it be permitted to draw conclusions from what one sees in travelling on the Continent, one might infer that competition with this country in many articles of trade is, at present at least, quite chimerical. Who that has seen what is offered to us in France and Germany in the shape of furniture, glass or china, can help thinking that were free trade established between these countries and ours, many of the poor, inferior articles of their commerce would be swept away to give place to really

good substantial ones such as we could furnish, or which they could themselves produce if exposed to the healthy influence of competition. In some departments of industry, especially the chemical, and more especially that of colouring matters, foreign competition is, I suppose, a very serious matter, but whether the evil is one that can be remedied by mechanical and educational measures seems to me doubtful. The fact is, that successful foreign competition may be due not only to superiority of education and training, but also to certain inscrutable, perhaps moral qualities, of which it is difficult to estimate the weight and bearing. As long as human beings exist there will always be differences of talent and disposition between individual and individual, and between one nation and another. In technical, as in other matters, special talents show themselves. The English have always been known for great mechanical undertakings, the Germans and French for the manufacture of chemicals, especially those of organic nature. That specialities such as we see developed on a large scale in the case of different nations are also seen on a smaller, in our own and other countries, is well known to everyone. Boots and shoes are made in one place, hats in another. The woollen trade flourishes in Yorkshire, and different branches of it in different towns. In this country, likewise, different branches of the cotton trade have localized themselves in various places. Why we should deplore this state of things I am at a loss to understand. Why should we not buy what we want where we can buy it

best and cheapest? Why should we determine to make all we require ourselves? These questions have often been asked and been answered by us in this country in one sense, and in other countries in a contrary sense."

If we wish to succeed, then, in the proper exploitation of our natural resources, we must employ properly-trained men for that purpose. In my inaugural address in the University some months ago, some extracts from which your Executive deemed of sufficient interest to this Association to merit publication in the Society's journal, I expressed myself in effect that the thoroughly-trained university man was the man to be looked to to help in this object. The true secret of successful manufacture consists in the close collaboration between the research chemist and the works manager. The usefulness of scientific training is now more than ever being demonstrated, and daily we see that the chemical industry which arises from the classroom and the laboratory is surely vindicating its superiority over the rule-of-thumb methods employed by the works foreman. To refer only to places of business with which I am familiar, a complete cycle—indeed, an overlapping of the circle—has been traversed in respect to the staffing of factories. Twenty and twenty-five years ago, trained chemists in the Old Country found lucrative positions in establishments large and small, but, as years progressed, the shortsightedness of employers to the adage that "the highest salaries yield the cheapest work" led their places to be filled by raw youths, whose

only pretention to chemical knowledge was their having spent from six months to two years in some analytical laboratory without any systematic training in general scientific subjects—in short, with utterly untrained minds on even general subjects. Such men, the employers found, could be got for a salary of from \$400 to \$500; they could be trained to do laboratory work in a machine-like way, and which, for the time, satisfied their business chiefs. The results of this might easily have been prophesied; either the youth became a mere drudge, or, if he displayed any originality and took an interest in his work sufficient to let him summon up courage to ask for a rise in salary, his place was most probably promptly filled by another at the same magnificent rate of pay. Foreign competition and advances in chemical knowledge soon demonstrated the shortsightedness of this policy, and now, I happy to say, places *can* be got by men with a thoroughly-sound academic training in science generally, which carry with them a reasonable salary and offer an unlimited field for the man with application and ability to further his own and his employer's interests.

And yet another matter which the manufacturer would do well to consider: In what manner does he intend to bring to the notice of his customers the goods he has to offer? I maintain that it is not sufficient for him to send out commercial travellers to push the sale of his products whose whole qualifications are that of being good salesmen; the manufacturer must come into personal contact with his customers, or employ

men to do so who are capable of directing them, understanding their desires, teaching them how best to employ their purchases and indicating which particular article is most suited to their wants. An eminent and successful electrical engineer in my own city — a brother of my colleague, Professor Mavor—told me that this method had been adopted by our cousins in the United States, and that the agents employed by all firms of any importance were men of sound education and intelligence, possessing a thorough grasp of all the details of the industry they represented. The natural consequence is the establishment of mutual collaboration between themselves and the customers whom they advise, and the customer, in turn, reciprocates the evident interest taken in his wants by consulting with the seller as to how he can best have his requirements met.

I would now like to bring before you, and particularly before those of my hearers whose business may from time to time present problems they find difficult to solve satisfactorily, the following suggestion contained in an address to the Society of Chemical Industry delivered by my friend, Mr. Beilby:

“This subject of Industrial Problems and Researches may be cleared of some difficulty if we begin by recognizing that industrial problems may be divided into two perfectly distinct classes. There are the problems the mere statement of which by a manufacturer would give his rivals a dangerous amount of insight into his operations and methods. No one who has the ability to evolve such

problems would be foolish enough to give his position away by publishing them.

“But, there is another class of problems, the publication of which will do good and not harm to the manufacturer. Where an industry is encumbered with some waste produce which is common to all of its manufacturers, all of whom are practically on a common level in its disposal, there is clearly room for the importation of skill and originality from outside of the industry. There are, further, those cases in which a considerable amount of research is required before the thing desired by the manufacturer can be even stated as a problem. There are many branches of industry which are practically without scientific experts who could initiate and carry on research. In such cases it appears to me quite worth while to try to educate the manufacturer to appreciate the value of pure knowledge, even if it does not immediately lead to practical results in his works. If we can induce such manufacturers to advertise their wants we shall have begun their education in a very hopeful way, and we trust that the response to their advertisement will be such as will increase their confidence in the value of research. I will only give one illustration, which may make my meaning clearer.

“The Scotch shale oil industry produces annually about 50,000,000 gallons of crude oil. Only about 70 per cent. of this oil is obtained as refined products, 30 per cent. being lost as coke, gas and tar. The tar is composed chiefly of basic nitrogenous substances, which are separated from the oil by

treatment with sulphuric acid. These 'acid tars' are partially washed with water for the recovery of sulphuric acid, and the washed tar is burned under the oil stills as fuel. Its value for this purpose is from 12s. to 18s. per ton. The total production of these tars in Midlothian and Westlothian is about 30,000 tons a year. Numerous attempts have been made to utilize these tars in some more advantageous way, but without success. After sharing in these attempts for many years, I have come to the conclusion that our knowledge of this material has not yet reached the stage at which we can profitably state problems about it. What is required is that it should be thoroughly investigated, so that we may know the pure substances of which it is mainly composed and their constitution and properties. Who will do this? The oil works chemists and their assistants have their time and attention fully occupied with the routine of the manufacture, therefore, they cannot make the research. If the various companies were to combine to establish a research laboratory, they would have to place themselves and the problems entirely in the hands of the chemist whom they appointed chief, and who might or might not be capable of bringing their research to a practical issue. Is this not a case in which it is better to invite chemists at large to take up the research? Are the chances of finding the right man for the work not enormously greater in this way than they would be in any other system of selection?"

In order to carry out this idea, then, let me suggest that when difficulties occur

recourse be had to those whose special training and circumstances permit of careful investigation of the subject. Where no secrecy is required and the services of the professional man consequently not called for, why not offer a prize for the satisfactory solution of the problem? At our universities there is always a sprinkling of graduates carrying on original research and who would be glad of the additional financial incentive to exercise their ingenuity and skill in clearing up the difficulty. At the same time they would be benefiting the manufacturer and indirectly the country while improving their own qualifications for an appointment in a sphere of future usefulness.



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